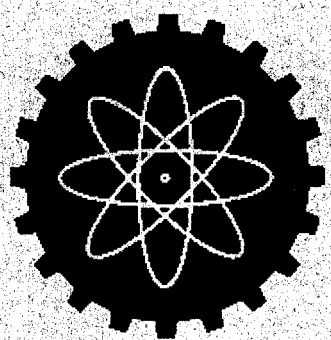
Assessment Annotations
for the Curriculum Frameworks

Science

Grades 3, 7, and 10



Missouri Department of Elementary and Secondary Education
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I. SCIENTIFIC INQUIRY
(Show-Me Standards, Science 7)

A. Processes of Scientific Inquiry
B. Investigations

K-12 Content Overview:

Scientific inquiry refers to the skills, habits of mind, and attitudes that promote lifelong scientific learning and the ability to apply scientific processes in all facets of life. Traditional approaches to teaching students scientific inquiry often do not give students an accurate perception of the true nature of the processes involved. The result is that many people have the impression that science is nothing more than "doing experiments", and following a rigid sequence of steps referred to as "the scientific method". In reality, the process is far from rigid. More imagination and inventiveness are involved in scientific inquiry than many people realize.

The best way for students to appreciate the true nature of scientific inquiry is for them to participate in scientific investigations based on real life questions that progressively approximate good science. This approach, however, will require major changes in typical school laboratory activities. Traditional laboratory activities are very unlike real science. They are often teacher-initiated, with the teacher not only specifying the question to be investigated, but also the experimental design, the data to be collected, and ways of organizing and interpreting the data. If students are to understand the process of science, they must make these decisions themselves. Time must be make for revision and repetition of experiments, and for presentations of results to other investigators, and even for response to criticism.

In addition to in-class laboratory activities that approximate good science, it is important to introduce student investigations. These investigations should become more sophisticated so that, before graduating from high school, students should carry out at least one major investigation. Such investigations, whether individual or group, might take weeks or months to conduct, and may take place in or out of school.

I. Scientific Inquiry A. Processes of Scientific Inquiry

What All Students Should Know	What All Students Should Be Able To Do	Sample Learning Activities
By the end of grade 2, all students should know that	*By the end of grade 2, all students should be able to*	*These sample activities offer ideas and are not meant to limit teacher or student resourcefulness.*
1. Tools, especially measuring, magnifying, and photographic ones, can give more information than by observing only using the senses.	a. use magnifiers and accurate simple metric measuring tools to observe and measure things in new situations and tasks. (1.4; 1.6)	• Select a square plot of grass and make observations with magnifiers and metric rulers.
2. Sometimes two people can observe the same object or event and describe it differently.	a. carefully distinguish actual observations from ideas and speculations about what was observed. Use information-processing skills to develop and clarify ideas and perspectives. (1.5; 1.7)	• Use a periscope and develop an explanation of how it works. Work in groups to compare ideas and devise new understanding based on the observations of the group.
3. Words, pictures, numbers, models, and sounds can be used to describe objects and events.	a. create communications that describe and compare things in terms of number, shape, texture, size, odor, sound, mass, color, and motion. (2.1; 2.4; 2.7)	• Given a group of vegetables, seashells, leaves, etc., describe to another person a single item so that the person can pick it out from the group.
4. Using tools, following directions, and/or asking for suggestions is helpful in building something or getting something to work better.	a. use simple tools, follow directions, and/or ask for suggestions to make things that can actually be used to perform a task or solve a problem. (1.5; 1.10; 3.2; 3.3)	• Use simple measuring tools to measure an object that is usually described qualitatively and describe it using numbers..
5. Objects and events are often observed and described quantitatively.	a. use whole numbers and simple fractions to measure, and describe things. (1.8)	• use simple measuring tools to measure an object that is usually described qualitatively and describe it using numbers.

What All Students Should Know	What All Students Should Be Able To Do	Sample Learning Activities
By the end of grade 4, all students should know that	*By the end of grade 4, all students should be able to*	*These sample activities offer ideas and are not meant to limit teacher or student resourcefulness.*
6. The accuracy of measurements is very important as inaccuracy often produce questionable results.	a. judge whether measurements and computations of quantities are reasonable. (1.7)	• Given a set of data, such as length, area, volume, mass, or time, identify values that are questionable (e.g., values that are much larger or smaller than the others).
	b. compare measurements and computations to typical values with which students have had prior experience. (1.10)	• Identify the appropriate units of measurements for common objects (e.g., amount of water in a cup, a bucket, or a swimming pool.)
7. Additional, more careful observations resolve different explanations for the same event.	a. use simple equipment to observe more detail, measure more accurately, and obtain more information about the environment in order to develop more accurate explanations. (1.4; 1.6)	• Participate in a simulated mystery in which incriminating "evidence" can be accurately determined only with the use of a microscope or hard lens.
8. Graphs, charts, maps, equations, and oral and written reports can be used to share the results of a scientific investigation and facilitate its discussion.	a. use a variety of methods, forms, and technologies to organize data into forms that are understandable. (1.4; 1.8; 2.1; 2.2; 2.4; 2.7)	• Measure the growth and development of organisms, such as bean plants or mealworms, and communicate observations using graphs, charts, and symbols.
9. problems can often be solved by physically altering specific components of a mechanical or biological system and observing the consequences.	a. select and apply appropriate technology and common materials for construction and repair of simple things and make safe electrical connections with various electrical devices for the purpose of solving a problem of performing a task. (1.10; 2.2; 2.3; 3.5; 3.7; 3.8)	• Construct a "doorbell" for people with hearing impairment using wires, batteries, bulbs, etc.

I. Scientific Inquiry B. Investigations

What All Students Should Know	What All Students Should Be Able To Do	Sample Learning Activities
By the end of grade 2, all students should know that	*By the end of grade 2, all students should be able to*	*These sample activities offer ideas and are not meant to limit teacher or student resourcefulness.*
1. The breadth and style of investigations depend on the questions asked.	a. create and refine ideas and questions about the world by asking for information, making careful observations, and trying things out. (1.1, 1.2, 1.6, 1.7) b. plan and conduct a simple investigation that includes formulating a question, gathering data, and constructing a reasonable explanation. (1.1; 1.2; 1.3; 4.1)	• Observe a discrepant event, such as two balls of similar mass and size that do not bounce the same height, and formulate questions that might lead to an explanation. • Predict what colors are present in the ink of different colored markers. Conduct an investigation and communicate an explanation.

What All Students Should Know	What All Students Should Be Able To Do	Sample Learning Activities
By the end of grade 4, all students should know that	*By the end of grade 4, all students should be able to*	*These sample activities offer ideas and are not meant to limit teacher or student resourcefulness.*
2. Most experiments involve changing something and then comparing it to something similar that has not been changed.	a. identify, discuss, and respond thoughtfully to a variety of conclusions and viewpoints and determine whether the claims are logical arguments based on repeated and properly controlled experiments. (1.5, 1.7, 2.3, 3.4, 3.6, 3.7)	• Design two paper airplanes, identical except for one attribute, measure and compare the distance thrown. Discuss whether this is a fair test of how far the planes fly or of which plane is better.

I. Scientific Inquiry A. Processes of Scientific Inquiry

What All Students Should Know	What All Students Should Be Able To Do	Sample Learning Activities
By the end of grade 8, all students should know that	*By the end of grade 8t, all students should be able to*	*These sample activities offer ideas and are not meant to limit teacher or student resourcefulness.*
1. Various statistical procedures are used to determine characteristics of sets of data as well as to determine the validity of experimental results.	a. apply mathematical procedures to investigations and data sets in order to determine patterns, relationships, and predictions. (1.6) b. find the mean and median of sets of data, calculate percent and ratios, and determine the units in which the values should be expressed. (1.8; 4.1)	• Use computer software to analyze data from a class experiment using statistical procedures. • Analyze the running speed of dinosaurs by measuring the distance between footprints on a simulated set of fossil tracks, then calculating the average stride length and the ratio of stride length to leg lengths. Compare these ratios to those of living animals, such as humans.
2. The use of tools allow more sophisticated means of observation and data collection, analyzation, storage, and retrieval.	a. real analog and digital meters that measure length, volume, mass, time, and temperature; use microscopes, cameras, and tape recorders for capturing information; and use computers to locate, select, identify, collect, store, manipulate, and receive information. (1.4; 1.8)	• Use an electronic temperature probe connected to a computer to accurately measure and graph temperature changes associated with a variety of insulating materials.
3. The comprehensiveness and sophistication of science are dependent on the ability to determine and use appropriate tools and technologies.	a. using appropriate tools and technologies, inspect, disassemble, and reassemble simple mechanical devices, assess what the various parts are for and what the effect would be of removing or changing individual parts, predict the most likely sources of malfunctions, and select and apply appropriate strategies to correct or prevent such malfunctions. (1.6; 3.1; 3.2; 3.3)	• After assessing the racing performance of a variety of toy cars, inspect those with poor performance. Predict the most likely sources of malfunctions and use appropriate strategies and tools (magnifiers, pliers, etc.) to correct the malfunctions.
4. Communication and the open sharing of information and knowledge are essential parts of scientific inquiry.	a. locate, read, listen to, and view various forms of information to interpret and evaluate; organize information in text, tables, and graphs; and use a variety of methods, forms, and technologies to describe the meaning and implications of the information. (1.4; 1.5; 1.6; 1.7; 1.8; 2.1; 2.7)	• Organize a science lesson using verbal communication, visual display, and hands-on experiences. Present this lesson to younger students.

I. Scientific Inquiry B. Investigation

What All Students Should Know	What All Students Should Be Able To Do	Sample Learning Activities
By the end of grade 8, all students should know that	*By the end of grade 8, all students should know that*	*These sample activities offer ideas and are not meant to limit teacher/student resourcefulness.*
1. A valid experiment, or "fair test", involves the manipulation of only one variable, while all others are held constant. Experiments should be repeated many times before accepting the results as true.	a. design and conduct scientific field and laboratory investigations which include an adequate number of repeated trials, unbiased sampling, accurate measurement and record-keeping, and a comparison to a control. (1.3; 3.1; 3.2; 3.3; 3.4)	• Design and complete an independent science investigation which includes repeated trials and is properly controlled.
2. Critical analysis of procedures, data, evidence, and conclusions developed during an investigation can be used to judge the quality and validity of the work.	a. analyze and evaluate arguments based on very small sets of data, experiments with few repeated trials, biased samples, or samples for which there was no control sample. (1.5; 1.7; 3.4; 3.7)	• Read and analyze selected articles from "supermarket tabloids", which commonly include questionable and highly exaggerated stories, and identify possible sources of error, bias, and incomplete information.

I. Scientific Inquiry A. Processes of Scientific Inquiry

What All Students Should Know	What All Students Should Be Able To Do	Sample Learning Activities
By the end of grade 12, all students should know that	*By the end of grade 12, all students should know that*	*These sample activities offer ideas and are not meant to limit teacher/student resourcefulness.*
1. Investigations may involve mathematical procedures to interpret observations, make predictions, describe sets of data, and determine the validity and significance of experimental results.	a. analyze experimental data to determine patterns, relationships, perspectives, and credibility; use computer spreadsheets, graphing, and database programs to assist in quantitative analysis; and consider the possible effects of measurement errors on calculations. (1.7, 1.8, 3.4, 3.6)	• Contact a professional scientist or statistician for advice about the design of an independent project and the statistical analysis of the data. Carry out the recommended analysis using appropriate computer software.
2. Publication and presentation of scientific work with supporting evidence are required for critique, review, and validation by the scientific community. The presentation of such work adds to the body of scientific knowledge and serves as background for subsequent investigations in similar areas.	a. present arguments based on scientific investigations which include detailed procedures, graphs and tables, and conclusions. Participate in follow-up discussions by responding to alternative positions. (1.8, 2.1, 2.3, 2.4)	• Participate in a student seminar in which formal presentations of independent science investigations, defense of arguments and conclusions, and critical questions about the methods and conclusions are given.
3. Controlling all variables that might influence an experiment is important. Sometimes it is not possible, for practical or ethical reasons, to control some conditions, but wide range of observations of natural occurrences can discern patterns.	a. make systematic observations (non-experimental) of natural objects or events to discern patterns, formulate explanations, support a thesis, or make predictions. (1.1, 1.6, 1.8)	• Design a series of systematic observations that may reveal relationships or patterns of behaviors of an animal species under natural conditions.
4. Technological tools and techniques extend human capabilities to perform investigations in more detail and with greater accuracy and precision.	a. apply technological knowledge and skills to analyze and troubleshoot common mechanical and electrical systems, checking for possible causes of malfunction, and formulate and test logical and creative improvements which prevent future malfunctions. (1.6, 1.10, 3.2, 3.3, 3.6)	• Using basic electrical components and tools, such as soldering gun and pliers, construct a set of light (photocell) probes that can be connected to a computer. Use the light probes to make a photogate timer which will measure the speed of a moving object in a controlled experiment.

I. Scientific Inquiry B. Investigations

What All Students Should Know	What All Students Should Be Able To Do	Sample Learning Activities
By the end of grade 12, all students should know that	*By the end of grade 12, all students should know that*	*These sample activities offer ideas and are not meant to limit teacher/student resourcefulness.*
1. The testing, revising, and occasional discarding of theories leads to increasingly better understanding, but not to absolute truth. New ideas, therefore, usually grow slowly from contributions by many investigators.	a. formulate questions for scientific investigations that indicate conceptual insights and a depth of understanding of the historical development of the idea or issue to be investigated. (1.1; 1.9; 3.1; 3.4)	• After conducting a literature search on a topic, contact an expert in the field of interest by e-mail, pose questions for the expert about the historical development of the key ideas involved. Based on collected information, formulate a question for scientific research which indicates an understanding of past research and future directions
2. Scientists attempt to improve objectivity of data observation and the academic integrity of their research by working in teams and seeking out possible sources of bias.	a. recognize and practice academic integrity while conducting investigations and developing solutions, seeking out sources of personal bias in the design of investigations. (3.4; 4.4)	• Design an investigation that involves observation of the behaviors of vertebrate animals. Develop a list of guidelines to avoid biased descriptions of behavior, recognizing that animal behaviors are often mistakenly interpreted in human terms. Submit procedures and collected data to other students for confirmation of objectivity.
3. The testing of an hypothesis requires a structured and rigorous investigative process.	a. design and conduct a full investigation including a comprehensive review of related literature; experimental design that is thoughtful and well-controlled, with adequate repeated trials; accurate measurement of data; some form of statistical treatment and display of data; thoughtful interpretation of data; and communication and defense of logical arguments supported by the finding. (1.1; 1.2; 1.3; 1.8; 2.1; 2.2; 3.1; 3.2; 3.3; 3.4; 3.5; 4.1)	• Design and carry out an independent science project following all of the guidelines of a nationally-recognized science fair. Submit the project for competition in the science fair.